have sensitive stamens, which, when disturbed close tightly around the style a few lines below the stigma.

An average fruit has from twenty to thirty tubercles, at first armed with a number of slender spines, which are deciduous in November and December, when the fruit begins to turn yellow.

The tubercles of the immature fruit are very prominent, but as the fruit ripens it increases considerably in size, becoming more succulent, and as a result the tubercles become much less conspicuous, sometimes entirely disappearing, leaving the fruit smooth save for the small bristle covered pulvini. The oval fruit when ripe is frequently two inches long, and one and one-half inches in diameter, well filled with smooth seeds similar to those in *O. arborescens.* As with *O. versicolor* the fruit occasionally remains green for the second year and becomes proliferous. It is clustered at the extremity of the stems of the previous year's growth, and when ripe the verticillate branches are pendulous from its weight.

The variety grows with the species, and its general form and habit of growth is somewhat similar.—J. W. TOUMEY, *University of Arizona.*

WINTER CHARACTERS OF CERTAIN SPORANGIA.[1]

(WITH PLATE XI)

THE gross characters of winter buds have been studied for a long time, but the histological characters of the sporangia have received comparatively little attention. It is an unfortunate fact that many otherwise excellent morphological papers are marred by incompleteness, and perhaps this is nowhere more apparent than in the case of those sporangia which attain some degree of development before the winter sets in, pass the cold season in a quiescent state, and resume development in the spring. It is hoped that the description of a somewhat miscellaneous collection of sporangia will not only show in what condition many buds pass the winter, but will incidentally enable students to make their series complete without waiting until the next year to fill in the gaps. The study of these dormant sporangia may also throw some light upon the significance of the resting stages of nuclei and cells. All the material upon which the following observa-

[1] Contributions from the Hull Botanical Laboratory. VIII.

tions are based, excepting Marsilea, was collected in the vicinity of Chicago.

OSMUNDA CINNAMOMEA L. — Rhizomes with strong buds were dug up November 11, 1897, the woolly covering was removed, and small parts of fertile branches were killed in chrom-acetic acid. The entire absence of mitotic figures showed that cell division had ceased. The average condition of the sporangia is shown in *fig. 1*. The sporogenous tissue has reached the spore mother cell stage, but the cells are still sharply angular, not yet showing any tendency to assume the spherical form which precedes division into tetrads. The cytoplasm is dense and not at all vacuolated. None of the nuclei show synapsis, but the chromatin is evenly distributed. There are usually two or three nucleoli. Some of the nucleoli are cyanophilous and others erythrophilous, even in the same nucleus, but on the whole one kind or the other predominates in any given sporangium. In both kinds there is considerable variation in the intensity of the stain, an indication that the nucleoli are undergoing changes. The tapetal cells, while rather poor in contents, are not breaking down like the cells between the tapetum and the epidermis.

MARSILEA QUADRIFOLIA L.— In the mature sporocarps collected November 10, after the leaves had rotted, both microspores and macrospores had nearly reached their full size, but were still uninucleate, germination under natural conditions not beginning until the next spring.

SELAGINELLA APUS Spring.—The development is carried further than in Marsilea, the prothallium attaining considerable size before the macrospore is shed.

PINUS LARICIO Poir.—Several stages were studied. Microsporangia gathered in October, January, and the following April are represented in *figs. 2, 3* and *4* respcetively. All are in the spore mother cell stage. This may be known by the fact that in a section of a sporangium the number of cells within the tapetum corresponds with the number of tetrads in late April sporangia. Guignard's rule that when the tapetum is differentiated the sporogenous tissue has reached the spore mother cell stage is sustained by all the microsporangia which I have examined. In October specimens (*fig. 2*) the spore mother cells have several small nucleoli which are quite uniformly cyanophilous. In the January material (*fig. 3*) the nucleoli are very inconspicuous, but reappear as the nuclei resume their growth in the spring (*fig. 4*). This figure shows three nuclei in synapsis, while the other nuclei have

the large size and prominent chromatin network which marks approaching division. The tapetum, now much compressed by the growing spore mother cells, is more sharply marked than in the January preparations. Collections of May 4 had the macrospore developed almost to the formation of archegonia.

PINUS BANKSIANA Lambert.—About a dozen macrosporangia, collected May 14, showed the macrospore mother cell, but material collected in a neighboring locality two weeks earlier showed an endosperm of several cells. Mitotic figures are very frequent in all of these spring collections, so that it is very possible that the macrosporangia also pass the winter in the spore mother cell stage.

CUPRESSUS LAWSONIANA Murray.—October microsporangia showed pretty uniformly the condition represented in *fig. 5*. The nuclei of the spore mother cells usually have a single prominent nucleolus which which is cyanophilous. No macrosporangia were studied.

TAXUS BACCATA CANADENSE Willd.—The microsporangia had reached the spore mother cell stage in October (*fig. 6*), but the nuclei were still rather small in comparison with the size of the cell. The tapetum is sharply differentiated, and its cells show no tendency to plasmolyze like the other cells of the sporangium wall. The macrosporangia were not studied.

TRILLIUM.—Miss Arma Smith[2] found microsporangia of Trillium in the spore mother cell stage in buds taken from beneath the frozen soil on April 5. In one case the mother cells were undergoing division. This suggests that cell division, which I feel certain does not take place under our usual winter conditions, may be resumed while the temperature is still near the freezing point. The present writer found the four potential macrospores in *T. recurvatum* collected April 10, at which time the plants were about two inches high.

HEPATICA ACUTILOBA.—Mottier[3] reports that material of this species collected in the middle of November was already too far advanced for studying the earlier stages of the embryo sac. Some of my material collected September 27 was young enough for the study of floral development, while the largest buds showed microsporangia in the pollen mother cell stage. Another collection taken in the spring while the ground was still frozen had pollen fully formed and embryo

[2]Abortive flower buds of Trillium. BOT. GAZ. **22**: 402. 1896.

[3]Contributions to the embryology of the Ranunculaceæ. BOT. GAZ. **20**: 298. 1895.

sacs ready for fertilization. It hardly seems probable that a macrosporangium would pass the winter in this stage.

SALIX.—Two years ago I studied a very complete series of microsporangia and macrosporangia in Salix[4] This series, containing sporangia collected in nearly every month of the year, showed that the microsporangia pass the winter in the spore mother cell stage. The midwinter pistillate flowers showed considerable variation; in some even the rudiment of the nucellus could not be distinguished, while in others the archesporium may have been present. Undoubted macrospore mother cells were not found until growth had been resumed in the spring.

POPULUS.—This genus shows practically the same conditions. Staminate flowers of *P. monilifera* Ait. collected in July showed the primary sporogenous cell. In October the sporangia had reached the spore mother cell stage, and could hardly be distinguished from the midwinter condition represented in *fig. 7*. No undoubted macrospore mother cells were found until growth had been resumed in the spring.

CORYLUS AMERICANA Walt.—Midwinter catkins showed the pollen grains apparently ready to be shed. The division into the tube nucleus and generative nucleus had already taken place (*fig. 8*).

ALNUS GLUTINOSA Willd.—This species showed about the same conditions as the last. The winter microsporangia appear so nearly like those collected just before the shedding of pollen in the spring that one figure might represent them both (*fig. 9*).

These examples are sufficient to show that sporangia of various plants pass the winter in very different stages of development, and it seems probable that all plants of a given species in a given locality pass the winter in about the same stage of development.

The spore mother cell seems to be a very usual halting place in the development of sporangia, but whether this is because the spore mother cell is better able to withstand unfavorable conditions, or for some other reason, it is at present impossible to decide. It has been noted by cytologists that the spore mother cell, in which the reduction of chromosomes takes place, requires a longer resting period than do the cells which precede or follow it. This may be seen even in annuals where the resting period is comparatively short, and is easily observed in those biennials and perennials which pass through all stages from floral development to seed in a single season. It is certain, however,

[4] Contributions to the life history of Salix. BOT. GAZ. **23**: 147–178. 1897.

that so long a period is not needed, since many plants which have reached the spore mother cell stage in the autumn resume their development when brought into the laboratory early in the winter. Again, my observations hardly allow the supposition that the sporangia merely continue their development until checked by cold weather. Of course every botanist has noticed dandelions blossoming in December and January, and fruit trees bearing a second set of flowers in late autumn. The change in the habits of north temperate plants when taken to a warmer climate is also well known, but they doubtless still have their resting periods. I should be inclined to think that the stage at which a sporangium rests for the winter is determined largely by its power to withstand unfavorable conditions. It has been noticed that the later the material is collected the more promptly it resumes its development. This suggests that the resting period is not one of absolute inactivity.— CHARLES CHAMBERLAIN, *The University of Chicago.*

EXPLANATION OF PLATE XI.

All figures are drawn with a Bausch and Lomb camera lucida, Zeiss ocular no. 2 and Zeiss apochromatic 2^{mm}, homogeneous immersion objective. The figures have been reduced by photography to one-half the size of the original drawings.

FIG. 1. Sporangium of *Osmunda cinnamomea* L. collected November 11, 1897.

FIG. 2. Microsporangium of *Pinus Laricio* Poir. collected October 1, 1896.

FIG. 3. The same, collected January 3, 1898.

FIG. 4. The same, collected April 4, 1896.

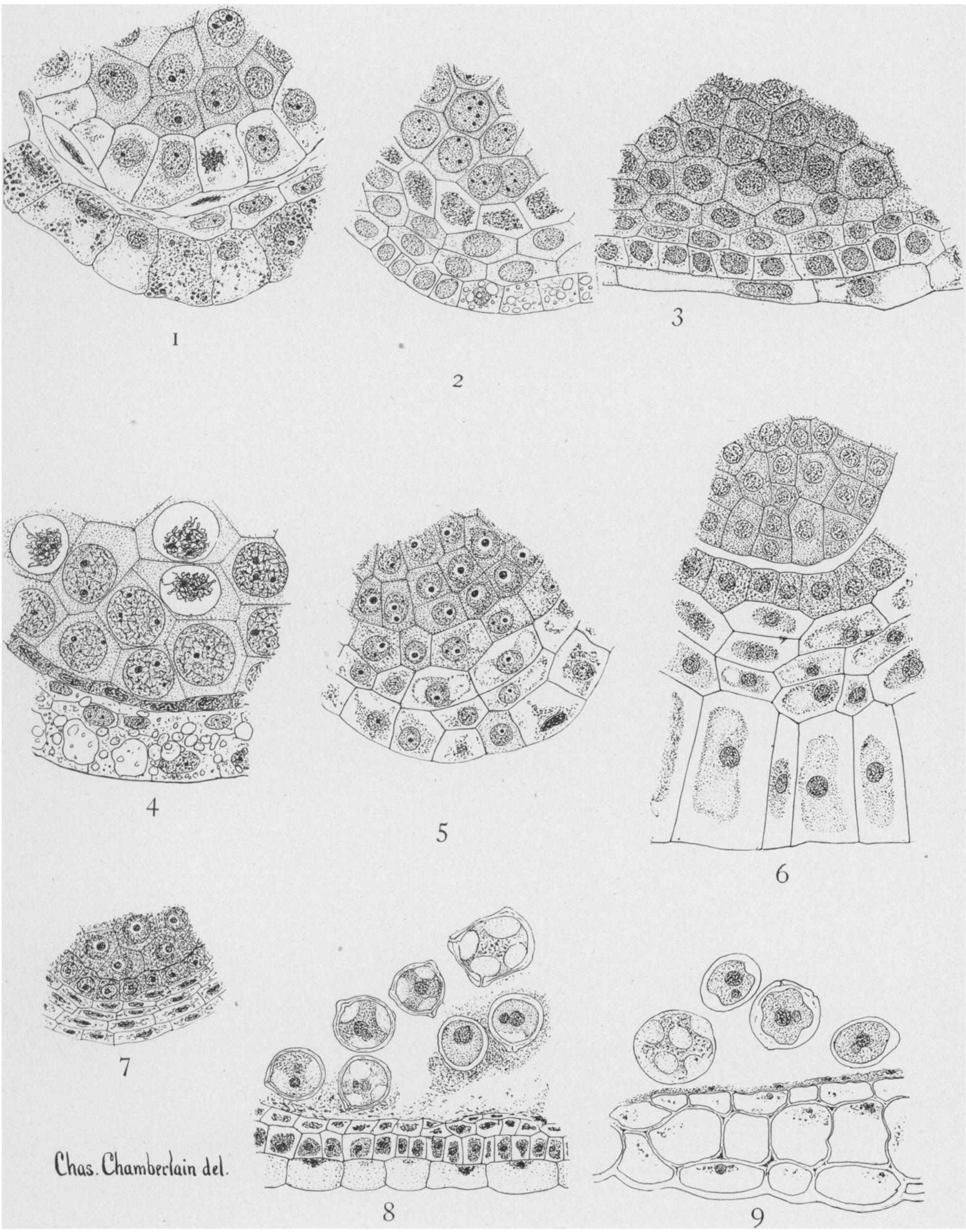
FIG. 5. Microsporangium of *Cupressus Lawsoniana* Murr., collected October 1, 1897.

FIG. 6. Microsporangium of *Taxus baccata, Canadense* Willd. collected October 1, 1897.

FIG. 7. Microsporangium of *Populus monilifera* Ait. collected January 25, 1896.

FIG. 8. Microsporangia of *Corylus Americana* Walt. collected December 7, 1897.

FIG. 9. Microsporangium of *Alnus glutinosa* Willd. collected April 12, 1897.



CHAMBERLAIN on WINTER SPORANGIA.